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PRELIMINARY MILITARY SPECIFICATION FOR MOLDED ELASTOMERIC BOOT --ETC(U)

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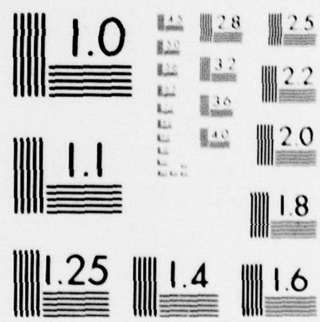

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Lab. Project 930-108
Technical Memorandum 1

LEVEL II

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PRELIMINARY MILITARY SPECIFICATION for MOLDED ELASTOMERIC BOOT SONAR TRANSDUCER HEAD MASS

9 Technical memo. no. 1

Material Sciences Division

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U. S. NAVAL APPLIED SCIENCE LABORATORY
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PRELIMINARY MILITARY SPECIFICATION
for
MOLDED ELASTOMERIC BOOT,
SONAR TRANSDUCER HEAD MASS

Lab. Project 930-108, Technical Memorandum 1
Subproject S2720 Task No. 11685

18 OCT 1968

MATERIAL SCIENCES DIVISION

Approved: D. H. Kallas
D. H. KALLAS
Associate Technical Director

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FLUSHING AND WASHINGTON AVENUES
BROOKLYN, NEW YORK 11251

Lab. Project 930-108
Technical Memorandum 1

Ref: (a) NAVSHIPS ltr OOV1D:GCM:pb, Ser 144 of 5 Jun 1968
(b) NASL Program Summary for Transducer Reliability, Subproject S2720, Task No. 11685 of 1 Oct 1968

Encl: (1) Preliminary Military Specification for Molded Elastomeric Boot, Sonar Transducer Head Mass

1. INTRODUCTION

a. The development program on elastomeric boots and transformer encapsulants for transducers of surface vessel and submarine sonar systems, ~~authorized in reference (a)~~, is continuing at the Naval Applied Science Laboratory (NASL).

b. This report deals specifically with the development of a preliminary specification for an elastomeric boot which can be molded to the head mass of a sonar transducer.

2. BACKGROUND

a. In enclosure (1) of reference (a), NASL was designated as the cognizant laboratory responsible for coordinating the Bonding/Booting/Encapsulation Committee (BBEC) functions of the Math-Modeling and Reliability Transducer (MART) Program. The objective of this program is to develop a prototype transducer which can be described by a mathematical model and adapted to computer programs. In addition, reference (a) alerted participating activities of impending meetings to plan and organize the MART Program.

b. Accordingly, an organizational meeting of the BBE Committee, chaired by Naval Ship Systems Command (Code OOV1D), was held at NASL on 29 and 30 of July 1968 and was attended by representatives of various Naval and commercial activities. Technical leadership was provided by NASL (Code 936).

c. The objectives of the meeting were as follows:

(1) To notify participants that preliminary specifications for procuring molded elastomeric boots and transformer encapsulants for the MART Program prototype sonar transducer was being developed by NASL.

(2) To review the state-of-the-art as it applies to the development of booting and encapsulating materials for sonar transducers, and

(3) To give participating Laboratories and contractors an opportunity to discuss problem areas with respect to materials, and to suggest solutions based on their own experiences.

d. In developing its approach to a solution of the materials problems, NASL proposed a set of tests and test procedures for inclusion in the required specifications. These items were discussed in some detail in the NASL presenta-

tion. Following the ensuing general discussion, the attendees were requested to submit comments, and to prepare additions, deletions or modifications which they considered essential to the program.

3. SPECIFICATION DEVELOPMENT

a. In accordance with the commitment outlined in reference (b), and on the basis of its own experiences and comments received from participating activities, NASL has prepared the preliminary specification requirements for procuring a molded elastomeric boot for the prototype sonar transducer. This preliminary specification, enclosure (1), is forwarded herewith.

b. Preparation of the preliminary specification requirements for procuring the transformer encapsulating material is in progress and will be forwarded within a few weeks.

4. ACTION REQUIRED

All addressees are requested to furnish comments, relative to enclosure (1), to the Naval Applied Science Laboratory, Flushing and Washington Avenue, Brooklyn, N.Y. 11251, the coordinating activity for BBEC. Comments are to be directed to Mr. H.P. Edelstein, Code 936, Area Code 212, 625-4500, Extension 282.

PRELIMINARY MILITARY SPECIFICATION

Molded Elastomeric Boot, Sonar Transducer Head Mass

1. SCOPE

1.1 This specification covers the requirements for an elastomeric boot for use on the head mass of high power sonar transducers.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified.

SPECIFICATIONS

<u>Federal</u>

<u>Military</u>

STANDARDS

<u>Federal</u>

Fed. Test Method Std. No. 601	Rubber; Sampling and Testing

<u>Military</u>

MIL-STD-407	Visual Inspection Guide for Rubber Molded Items
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes

<u>Drawings</u>

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

2.2 <u>Other publications</u> - The following documents form a part of this document to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

D149	Tests for Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies
D150	Tests for A-C Loss Characteristics and Dielectric Constant (Permittivity) of Solid Electrical Insulating Materials
D257	Tests for D-C Resistance or Conductance of Insulating Materials
D395	Tests for Compression Set of Vulcanized Rubber
D412	Tension Testing of Vulcanized Rubber
D429	Tests for Adhesion of Vulcanized Rubber to Metal
D471	Test for Change in Properties of Elastomeric Vulcanizates Resulting from Immersion in Liquids
D2240	Test for Indentation Hardness of Rubber and Plastics by Means of a Durometer

(Application for copies of ASTM standards should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103).

3. REQUIREMENTS

3.1 Qualification - The molded elastomeric boot material furnished under this specification shall be a product which has been tested, and passed the qualification tests specified herein, and has been listed on or approved for listing on the applicable qualified products list.

3.2 Material - The elastomeric boot shall be molded directly onto the head mass of the transducer and shall be of the shape required and shall have the dimensions specified in the drawing (Figure 1) (omitted in this draft)which forms a part of this specification.

3.2.1 Suitability - The molded elastomeric boot shall protect the head mass against such conditions as corrosion and cavitation-erosion. In addition, the boot shall prevent an excessive amount of water from permeating into the chamber housing the ceramic elements.

3.3 Characteristics and Performance

3.3.1 Density - When tested as specified in 4.8.1, the density of the boot material shall be gm/cm^3.

3.3.2 Hardness -

3.3.2.1 "As Received" Condition - When tested as specified in 4.8.2.1, the hardness of the boot material, in the "as received" condition, shall be points.

3.3.2.2 After Low Temperature Conditioning - When tested as specified in 4.8.2.2, the hardness of the boot material shall not increase by more than points over that obtained in the "as received" condition. In addition, after recovery at room temperature the hardness of the boot material shall not increase by more than points over that obtained in the "as received" condition.

3.3.3 Tensile Strength -

3.3.3.1 "As Received" Condition - When tested as specified in 4.8.3.1, the tensile strength of the boot material, in the "as received" condition, shall be pounds per square inch (minimum).

3.3.3.2 After Oil Aging - When tested as specified in 4.8.3.2, the tensile strength of the boot material, after oil aging, shall be not less than percent of the tensile strength in the "as received" condition.

3.3.4 Modulus (Tensile Stress) - When tested as specified in 4.8.4, the modulus at percent elongation of the boot material in the "as received" condition shall be pounds per square inch (minimum).

3.3.5 Ultimate Elongation - When tested as specified in 4.8.5, the ultimate elongation of the boot material in the "as received" condition shall be percent (minimum).

3.3.6 Tear Resistance - When tested as specified in 4.8.6, the tear resistance of the boot material shall be pounds per inch thickness (minimum).

3.3.7 Compression Set - When tested as specified in 4.8.7, the compression set of the boot material shall be percent (maximum).

3.3.8 Adhesion - When tested as specified in 4.8.8, the adhesion of the boot material to the head mass shall be pounds per inch of width (minimum).

3.3.9 Non-Destructive Void and Blister Test - When tested as specified in 4.8.9, the rubber boot adhered to the head mass shall

3.3.10 Ozone Resistance - When tested as specified in 4.8.10, the ozone resistance rating of the boot material shall be percent (minimum).

3.3.11 Volume Swell -

3.3.11.1 In Sea Water - When tested as specified in 4.8.11.1, the volume swell of the boot material shall be percent (maximum).

3.3.11.2 In Oil - When tested as specified in 4.8.11.2, the volume swell of the boot material shall be percent (maximum).

3.3.12 Cavitation - Erosion - When tested as specified in 4.8.12, the test specimens shall not show damage such as perforation, blistering, erosion, eruptions or cracks. In addition, the average loss in volume of the specimens shall not exceed cubic centimeters.

3.3.13 Permeability - When tested as specified in 4.8.13, the permeability of the boot material to water shall be (maximum).

3.3.14 Volume Resistivity -

3.3.14.1 "As Received" Condition - When tested as specified in 4.8.14.1, the volume resistivity of the boot material, in the "as received" condition, shall be

3.3.14.2 After Immersion - When tested as specified in 4.8.14.2, the volume resistivity of the boot material, after immersion in water, shall be

3.3.15 Dielectric Constant -

3.3.15.1 "As Received" Condition - When tested as specified in 4.8.15.1, the dielectric constant of the boot material at frequencies of 1,000 and 10,000 Hz, in the "as received" condition, shall be and , respectively.

3.3.15.2 After Immersion - When tested as specified in 4.8.15.2, the dielectric constant of the boot material at frequencies of 1,000 and 10,000 Hz, after immersion in water, shall be and , respectively.

3.3.16 Dielectric Strength -

3.3.16.1 "As Received" Condition - When tested as specified in 4.8.16.1, the dielectric strength of the boot material, in the "as received" condition, shall be

3.3.16.2 After Immersion - When tested as specified in 4.8.16.2, the dielectric strength of the boot material, after immersion in water, shall be .

3.3.17 Sound Velocity - When tested as specified in 4.8.17, the velocity of sound in the boot material shall be

3.3.18 Rho-c - The Rho-c of the boot material (product of density and sound velocity) shall be calculated as noted in 4.8.18 and shall be

3.3.19 Workmanship - When inspected as specified in 4.8.19, the assembly of the boot material on the head mass shall be first class in all respects. The exposed surfaces of the boot shall be free from blisters, pinholes, voids, seam marks, bloom, wax, silicone release agent and in addition shall be smooth and free from waviness. The boot material molded on the head mass shall be of uniform thickness.

4. Quality Assurance Provisions

4.1 Responsibility For Inspection

4.1.1 Contractor's Quality Assurance System

4.1.2 Government Verification

4.1.3 Preproduction Inspection

4.1.4 Production Inspection

4.1.5 Production Control Inspection

4.2 Sampling

4.3 Lot

4.4 Classification of Tests

4.5 Quality Conformance Tests

4.7 Test Conditions

4.8 Test Methods

4.8.1 Density - This test shall be made in accordance with Method 14011 of Fed. Test Method Std. No. 601. The test specimen shall consist of a 1 by 2 by 0.070 ± 0.005 inch thick section cut from a tensile sheet of boot material. The density in grams per cubic centimeter shall be calculated. Three specimens shall be tested and the results averaged.

4.8.2 Hardness -

4.8.2.1 "As Received" Condition - This test shall be made in accordance with ASTM Method D2240 using a Shore A Durometer. The test specimen shall consist of the rubber boot molded to the head mass. Readings of the Shore A Durometer shall be taken 15 seconds after the instrument contacts the boot material. Three readings of the hardness at various locations on the face of the molded rubber boot shall be taken and the results averaged.

4.8.2.2 After Low Temperature Conditioning - The hardness test described in 4.8.2.1 shall be repeated on the same molded rubber boot except that the boot shall be conditioned for 166 ± 2 hours at a temperature of 0° ± 2°C prior to test. The molded rubber boot shall then be returned to room temperature for a period of 72 ± 2 hours and the hardness test repeated. Three hardness readings at various locations on the molded rubber boot shall be taken for each condition of test and the results averaged.

4.8.3 Tensile Strength

4.8.3.1 "As Received" Condition - This test shall be made in accordance with ASTM Method D412 on three test specimens die cut with the grain from a 6 by 6 by 0.070 ± 0.005 inch sheet of boot material.

4.8.3.2 After Oil Aging - This test shall be made in accordance with ASTM Method D471 on three test specimens die cut with the grain from a 6 by 6 by 0.070 ± 0.005 inch sheet of boot material. The tensile specimens shall be immersed in ASTM reference oil No. 1 for a period of 22 ± 1 hours at a temperature of 158° ± 2°F., following which the immediate deteriorated properties of the specimens shall be determined.

4.8.4 Modulus (Tensile Stress) - This property shall be determined in accordance with ASTM Method D412 at 300 percent elongation on the tensile strength specimens tested in 4.8.3.1.

4.8.5 Ultimate Elongation - This property shall be determined in accordance with ASTM Method D412 on the tensile strength specimens tested in 4.8.3.1.

4.8.6 Tear Resistance - This test shall be made in accordance with Method 4221 of Fed. Test Method Std. No. 601. The test specimen shall consist of a 1 by 2 by 0.070 ± 0.005 inch thick section cut from a tensile sheet of boot material. The cut shall extend 1-1/2 inches down the center of specimen. Three specimens shall be tested and the results averaged.

4.8.7 Compression Set - This test shall be made in accordance with ASTM Method D395 on three Type 1 specimens which shall be cut with a circular die from a 6 by 6 by 0.500 ± 0.010 inch piece of boot material. Method B shall be used and the specimens shall be conditioned for 22 ± 1/4 hour at a temperature of 158° ± 2°F. The average compression set of the specimens shall be calculated.

4.8.8 Adhesion - This test shall be made in accordance with Method B of ASTM Method D429 except that the test sample shall consist of a molded rubber boot vulcanized to the head mass. Three sets of knife cuts 1 inch apart, separated by 1/4 inch and extending the entire length of the boot shall be made through the boot material down to the head mass. One end of each of the three 1-inch wide strips of boot material so formed shall be separated from the head mass to provide tab ends for attachment to the load measuring head of the tensile machine. The head mass shall be attached to a jig secured to the tensile machine and so arranged that the direction of pull on the specimen shall be as nearly perpendicular as possible. The three 1-inch wide strips of boot material shall be tested and the average adhesion of the molded boot material to the head mass shall be calculated.

4.8.9 Non-Destructive Void and Blister Test -

4.8.9.1 Apparatus

4.8.9.2 Procedure

4.8.10 Ozone Resistance

4.8.10.1 Apparatus - The apparatus used for this test shall be a St. Joe Ozone Flex Tester sold by Scott Testers, Inc., 101 Blackstone St., Providence, R.I. The tester is essentially a glass-enclosed working chamber in which aluminum jaws flex five rubber specimens in air containing approximately 50 parts of ozone per hundred million parts of air. A built-in time switch automatically turns on the jaw flex motor 10 minutes out of the hour. When the motor is running, it flexes the specimens through an angle of 120 degrees at the rate of 9.3 cycles per minute. At the end of the 10-minute flex period, the jaws

automatically assume the bend position through the action of a cam-operated switch. The measurement of the degree of cracking caused by ozone is made on an attack rater which consists of a beam balance constructed to give a measure of the force required to hold a specimen bent to a degree comparable to that experienced in the exposure test. Ozone resistance ratings are obtained by expressing bend modulus readings after testing as a percentage of readings before testing.

4.8.10.2 Procedure - Five test specimens, each 1/2 by 1 by 0.070 ± 0.005 inch shall be cut from the tensile sheets of boot material. The initial bend modulus of the specimens shall be determined on the attack rater. Following this, the specimens shall be exposed in the ozone flex tester for a period of 7 hours and then the bend modulus of the specimens after aging shall be determined. The ozone resistance rating of the specimens shall be obtained by expressing the bend modulus rating after testing as a percentage of the reading before testing. The average ozone resistance rating shall be calculated.

4.8.11 Volume Swell

4.8.11.1 In Sea Water - This test shall be made in accordance with ASTM Method D471 on three specimens, each measuring 1 by 2 by 0.070 ± 0.005 inch, which shall be cut from the tensile sheet of boot material. After weighing the specimens in air and in water they shall be immersed in a 3 percent solution of synthetic sea water for 166 ± 2 hours at 158° ± 2°F. As described in ASTM Method D471, the specimens shall be weighed again in air and in water and average change in volume shall be determined.

4.8.11.2 In Oil - This test shall be made in accordance with ASTM Method D471 on three specimens, each measuring 1 by 2 by 0.070 ± 0.005 inch, which shall be cut from the tensile sheet of boot material. After weighing the specimens in air and in water they shall be immersed in ASTM reference oil No. 1 for a period of 22 ± 1 hours at a temperature of 158° ± 2°F. As described in ASTM Method D471, the specimens shall be weighed again in air and in water and the average change in volume shall be determined.

4.8.12 Cavitation - Erosion - The apparatus and method described below for this test are being considered by the American Society for Testing and Materials Tech Committee G-2 as a standard method of test for cavitation-erosion resistance of materials.

4.8.12.1 Apparatus - The magnetostriction apparatus shown in Figure 2 shall be used for this test. This apparatus consists essentially of a transducer stack, an exponential horn attached thereto, and electronic equipment for driving and monitoring the transducer.

Short, cylindrical test plugs 5/8-inch diameter, are attached to the free end of the horn. During test the free end of the horn is immersed in synthetic sea water and driven so that the face of the plug vibrates perpendicularly at a fixed frequency and amplitude. The test specimen exposed to cavitation is the face of the test sample attached to the plug.

4.8.12.2 Procedure - A sample of boot material 3/4-inch in diameter by 0.070 $\pm$ 0.005 inches thick shall be cut from the 6 by 6 by 0.070 $\pm$ 0.005 inch tensile sheet. The surface of the sample to be bonded to the plug shall be buffed using a No. 80 to No. 200 fine grit power disk. The buffed surface shall be bonded to the grit-blasted face of a 5/8-inch diameter mild steel plug using a 100% reactive, room temperature curing epoxy adhesive. After cure of the adhesive, the coating margins shall be buffed to the 5/8-inch diameter of the steel plug. The weight of the sample assembled on the plug shall be measured. The test specimen (plug and bonded overlay) then shall be screwed into the lower end of the 13.5KHz exponential horn using a silicone grease lubricant and tightened by wrench. After immersion of the specimen in synthetic sea water to a 1/8-inch depth, the vibration frequency shall be adjusted to resonance (approximately 13.5KHz) and the power raised to obtain a vibration of approximately 2 mils double amplitude. The temperature of the synthetic sea water shall be maintained at approximately 75°F throughout the exposure of the specimen. The test shall be continued for a period of 10 hours. Following the test, the face of the specimen shall be examined for damage such as perforation, blistering, erosion, eruptions or cracks. In addition, the specimen shall be weighed and the weight loss due to the cavitation erosion test shall be determined. The volume loss shall be calculated from the equation:

$$V.L. = \frac{W.L.}{D}$$

where V.L. = Volume loss of specimen, cm^3
W.L. = Weight loss of specimen, gms
D = Density, gms /cm^3

Three specimens shall be tested and the results averaged.

4.8.13 Permeability

4.8.13.1 Apparatus - The apparatus used for this test is shown in Figure 3. It consists essentially of two evacuated chambers which are separated by a 0.010 to 0.030 inch thick membrane of the boot material. The right chamber is connected via stopcocks 1 and 2 to a vacuum source capable of producing a vacuum of 10^{-3} mm mercury and via stopcock 3 to the flask on the right side. This flask contains

a saturated solution of magnesium chloride; is immersed in a constant temperature water bath maintained at 40 $\pm$ 0.1°C and is connected to the vacuum system via stopcock 4. The left chamber consists of a receiving flask separated from a McLeod vacuum gage by stopcock 5. The receiving flask has a large volume (about 5 liters) to minimize the surface to volume ratio and thus minimize the error caused by water adsorption on the surface. The capillary of the McLeod vacuum gage is heated to between 80 to 90°C to avoid condensation of water vapor, the pressure of which it measures. The left chamber is also connected to the vacuum system via stopcocks 1 and 5, and is connected to the right chamber via stopcock 2.

4.8.13.2 Procedure - The test specimen shall consist of a 2 by 6 by 0.010 to 0.030 inch thick piece of boot material cut from the 6 by 6 by 0.070 $\pm$ 0.005 inch tensile sheet and buffed to the required thickness. The specimen (identified as sample on the drawing) shall be positioned between butyl rubber gaskets and wire screens. The magnesium chloride solution which fills less than half of the flask is frozen, stopcock 3 is closed, stopcock 4 is opened and the flask evacuated. Stopcock 4 is then closed, the salt solution thawed, frozen again and evacuated again. This procedure shall be repeated two times to make sure that all air in the flask is removed. Stopcock 4 is then closed. Stopcocks 1, 2 and 5 are then opened and the apparatus evacuated at least 1 hour but preferably a longer period of time (i.e. as much as 16 hours). Stopcock 1 shall then be closed and the apparatus checked for leaks by reading the McLeod gage at half-hour intervals. If there are no leaks, stopcock 2 shall be closed, stopcock 3 opened and the McLeod gage read at intervals; the period of which depends on the sample to be tested and the progress of the test. The pressure of the McLeod gage in mm mercury shall be plotted versus time in hours until the slope is a straight line. The water permeability (W.P.) of the specimen shall be calculated from the following:

$$W.P. = \frac{s \times t \times V \times 7.34\times10^{-7}}{a \times p \times T}$$

where W.P. = Water permeability, gms water/sq.cm/cm/hr./mm Hg
s = Slope of plot, mm Hg per hr.
t = Thickness of specimen, mils
V = Volume of left chamber, cubic centimeters
7.34×10^{-7} = Factor which includes the gas constant, the molecular weight of water and a conversion factor from mils to centimeters.
a = Area of specimen that is being permeated, square cm
p = Water vapor pressure prevailing on the right side of the apparatus, which is equal to 17.5 mm mercury for a saturated solution maintained at 40°C
T = Absolute room temperature, degrees K

4.8.14 Volume Resistivity

4.8.14.1 "As Received" Condition, - This test shall be made in accordance with ASTM Method D257 on three specimens cut from the 6 by 6 by 0.070 $\pm$ 0.005 inch tensile sheets of the boot material which shall be in the "as received" condition. The average volume resistivity of the specimens shall be determined.

4.8.14.2 After Immersion - This test shall be made in accordance with ASTM Method D257 on three specimens cut from the 6 by 6 by 0.070 ± 0.005 inch tensile sheets of the boot material which have been immersed in 3 percent synthetic sea water solution for 30 days at a temperature of 158° ± 2°F. After immersion, the specimens shall be blotted dry to remove surface water and shall be tested within 5 minutes after removal from the sea water solution. The average volume resistivity of the specimens after immersion shall be determined.

4.8.15 Dielectric Constant -

4.8.15.1 "As Received" Condition - This test shall be made in accordance with ASTM Method D150 at frequencies of 1,000 and 10,000 Hz on three specimens cut from the 6 by 6 by 0.070 ± 0.005 inch tensile sheets of the boot material which shall be in the "as received" condition. The average dielectric constant of the specimens at each frequency shall be determined.

4.8.15.2 After Immersion - This test shall be made in accordance with ASTM Method D150 at frequencies of 1,000 and 10,000 Hz on three specimens cut from the 6 by 6 by 0.070 ± 0.005 inch tensile sheets of the boot material which have been immersed in 3 percent synthetic sea water solution for 30 days at a temperature of 158° ± 2°F. After immersion, the specimens shall be blotted dry to remove surface water and shall be tested within 5 minutes after removal from the sea water solution. The average dielectric constant of the specimens at each frequency shall be determined.

4.8.16 Dielectric Strength

4.8.16.1 "As Received" Condition - This test shall be made in accordance with ASTM Method D149 on three specimens cut from the 6 by 6 by 0.070 ± 0.005 inch tensile sheets of the boot material which shall be in the "as received" condition. The average dielectric strength of the specimens shall be determined.

4.8.16.2 After Immersion - This test shall be made in accordance with ASTM Method D149 on three specimens cut from the 6 by 6 by 0.070 ± 0.005 inch tensile sheets of the boot material which have been immersed in 3 percent synthetic sea water solution for 30 days at a temperature of 158° ± 2°F. After immersion, the specimens shall be blotted dry to remove surface water and shall be tested within 5 minutes after removal from the sea water solution. The average dielectric strength of the specimens after immersion shall be determined.

4.8.17 Sound Velocity

4.8.17.1 Apparatus - The apparatus used for this test is shown in Figure 4 and consists of the following:

(a) An ultrasonic flaw detector is used as a source of pulsed, ultrasonic waves in the 0.7 to 5 MHz range. The flaw detector also provides a means for detecting, amplifying, and finally displaying the waves on a cathode - ray tube screen.

(b) The ultrasonic velocity comparator consists of a corrosion-resistant tank which is filled with distilled, air-free water. An ultrasonic reflector consisting of a moveable metal disc is suspended in a tank and its position is adjusted and measured by means of a micrometer screw, a 20 cm. scale, and vernier mechanism. The reflector faces an ultrasonic transducer installed in a port at one end of the tank.

(c) A variable attenuator serves to equalize signal amplitudes received from the comparator and through-transmission measurement.

(d) The through-transmission portion of the measurement is conducted in a fish tank also containing distilled, air-free water. Adjustable supports are bridged across the tank to hold and permit adjustment of two ultrasonic search tubes, which contain the through-transmission transducers.

(e) Transducers are high output, ceramic, immersion types selected for resonance at the desired frequency of the measurement which should be within the frequency range of the flaw detector. A total of three transducers are used. The two transducers of the through-transmission measurement are axially aligned and face each other on either side of the specimen, allowing a short water path between each transducer and the specimen. The comparator transducer is installed facing the reflector in a water tight housing at one end of the comparator tank.

(f) Self-grounding and shielding conductors, search tubes, and connectors are used throughout the system.

4.8.17.2 Specimen - Test specimens of the boot material shall be 6 inch by 6 inch rectangles or 6 inch diameter discs with flat parallel surfaces. The thickness of the specimen shall be a minimum of 1/2 inch. Maximum thickness is limited only by the space available between transducers and the velocity comparator range. The thickness of the specimens shall be measured to the nearest 0.001 cm. in the area of measurement.

4.8.17.3 Procedure - The test specimen shall be positioned in the distilled water filled test tank between the transmitting and receiving transducers. The received signal shall be transmitted through the equalizing attenuator to the flaw detector receiver terminal. Simultaneously, a signal shall be transmitted from the velocity comparator transducer to its reflector plate and the reflected signal returned to the transducer in the velocity comparator by pulse-echo action. This latter signal is also sent to the signal equalizing attenuator and thereby to the flaw detector. By use of the signal equalizing attenuator the two signals shall be made approximately equal in height. The leading edge of the comparator signal is made to coincide with the leading edge of the specimen through-transmission signal by adjustment of the position of the comparator reflector. The reflector position shall then be read from the scale and vernier dial to the nearest 0.001 cm. The specimen shall be removed without disturbing the straddling transducers and leading edge coincidence of the two signals re-established and reflector position re-measured. The movement of the reflector, which is the difference between the two position measurements is thus accurately measured and constitutes the basis for computing sound velocity of the specimen from the following formula:

$$V = \frac{V_W L}{L - 2 (M2 - M_1)}$$

where V = Velocity of sound in boot material, cm/sec
V_w = Velocity of sound in distilled water at the temperature of test, cm/sec = 1.49×10^5 cms/sec at 23°C ± 0.027 cms/sec/°C
L = Thickness of specimen, cm
M_2 = Position of comparator reflector without specimen, cm
M_1 = Position of comparator reflector with specimen, cm

4.8.18 Rho-c - The Rho-c of the boot material shall be calculated from the product of density (gm per cm^3) determined as described in 4.8.1 and sound velocity (cm per sec) determined as described in 4.8.17. The temperature at which the sound velocity is measured shall be reported.

4.8.19 Workmanship - The boot material assembled on the head mass shall be subjected to visual examination to make sure that the workmanship is first class in all respects. The exposed surfaces of the boot shall be inspected visually for blisters, pinholes, voids, seam marks, bloom, wax and silicone release agent. The exposed surfaces shall be smooth and free from waviness. The boot material molded on the head mass shall be of uniform thickness.

5. Preparation For Delivery

5.1 Packaging

5.2 Packing

5.3 Marking

6 Notes

6.1 Intended Use

6.2 Ordering Data

6.3 Qualification

Enclosures to Specification

Figure 2 - Photo L-21633-2 - Schematic Diagram of Magnetostriction Apparatus
Figure 3 - Photo L-21633-3 - Permeability Apparatus
Figure 4 - Photo L-21633-4 - Schematic Diagram of Ultrasonic Velocity Measuring System

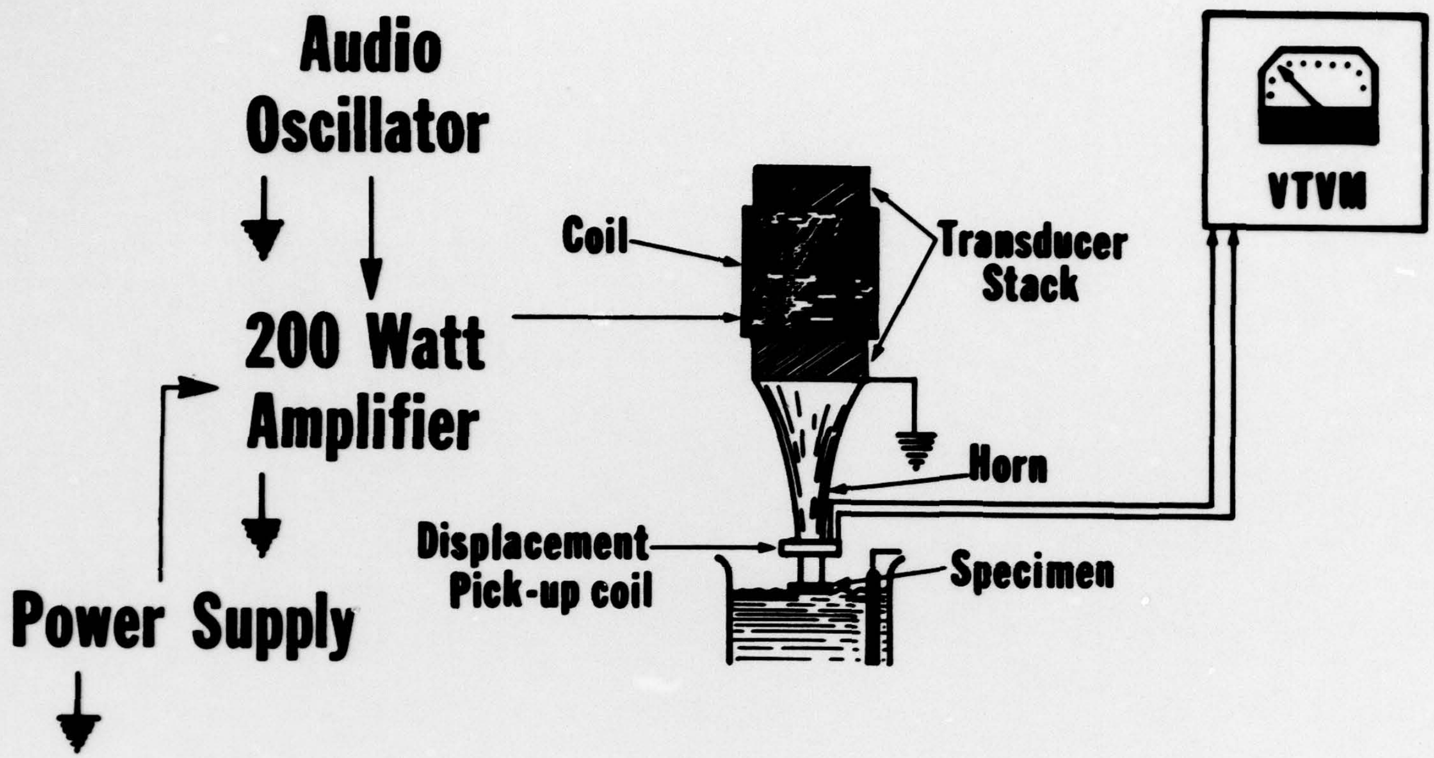

PHOTO L-21633-2

FIGURE 2 - SCHEMATIC DIAGRAM OF MAGNETOSTRICTION APPARATUS

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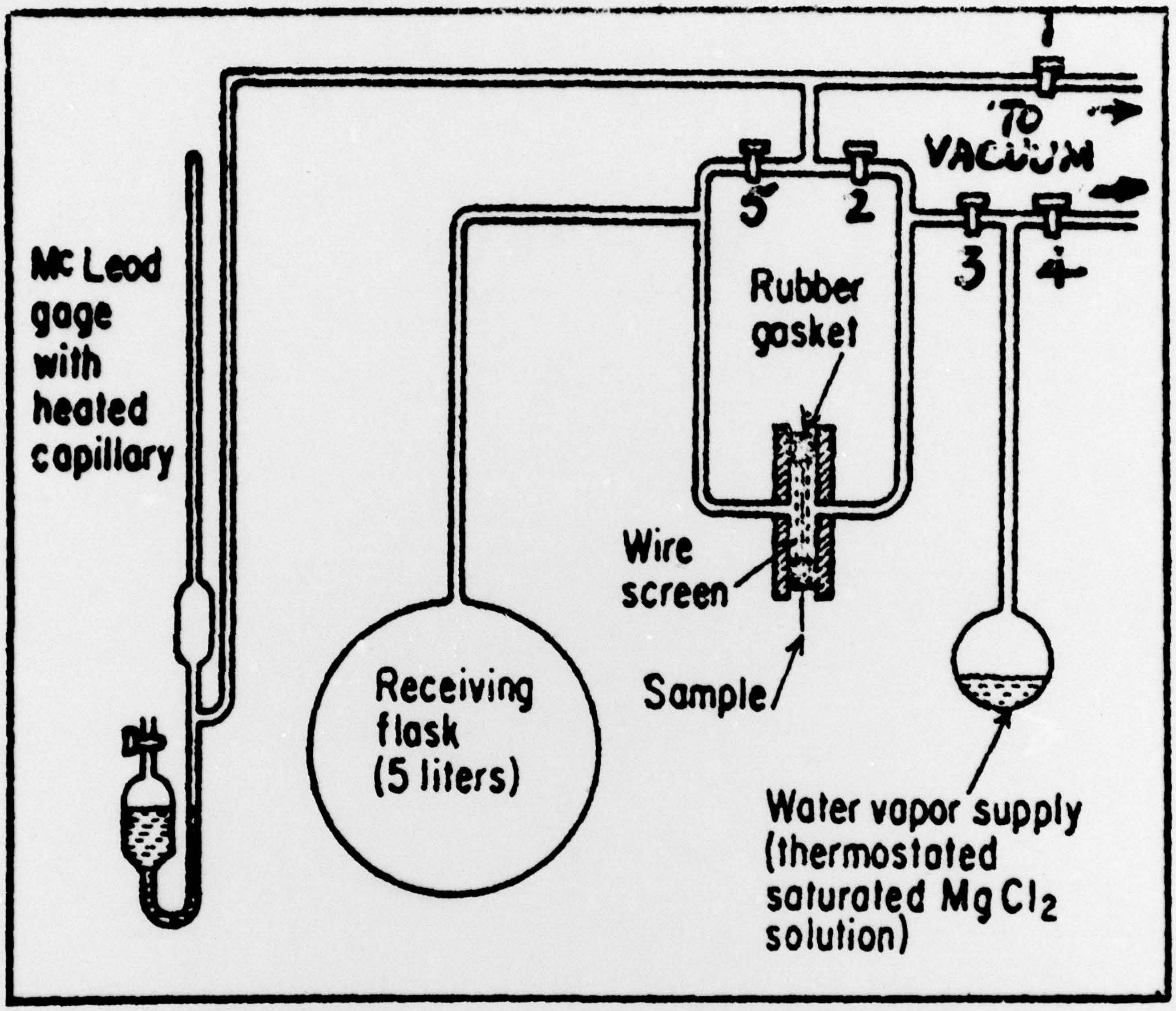

PHOTO L-21633-3

FIGURE 3 - PERMEABILITY APPARATUS

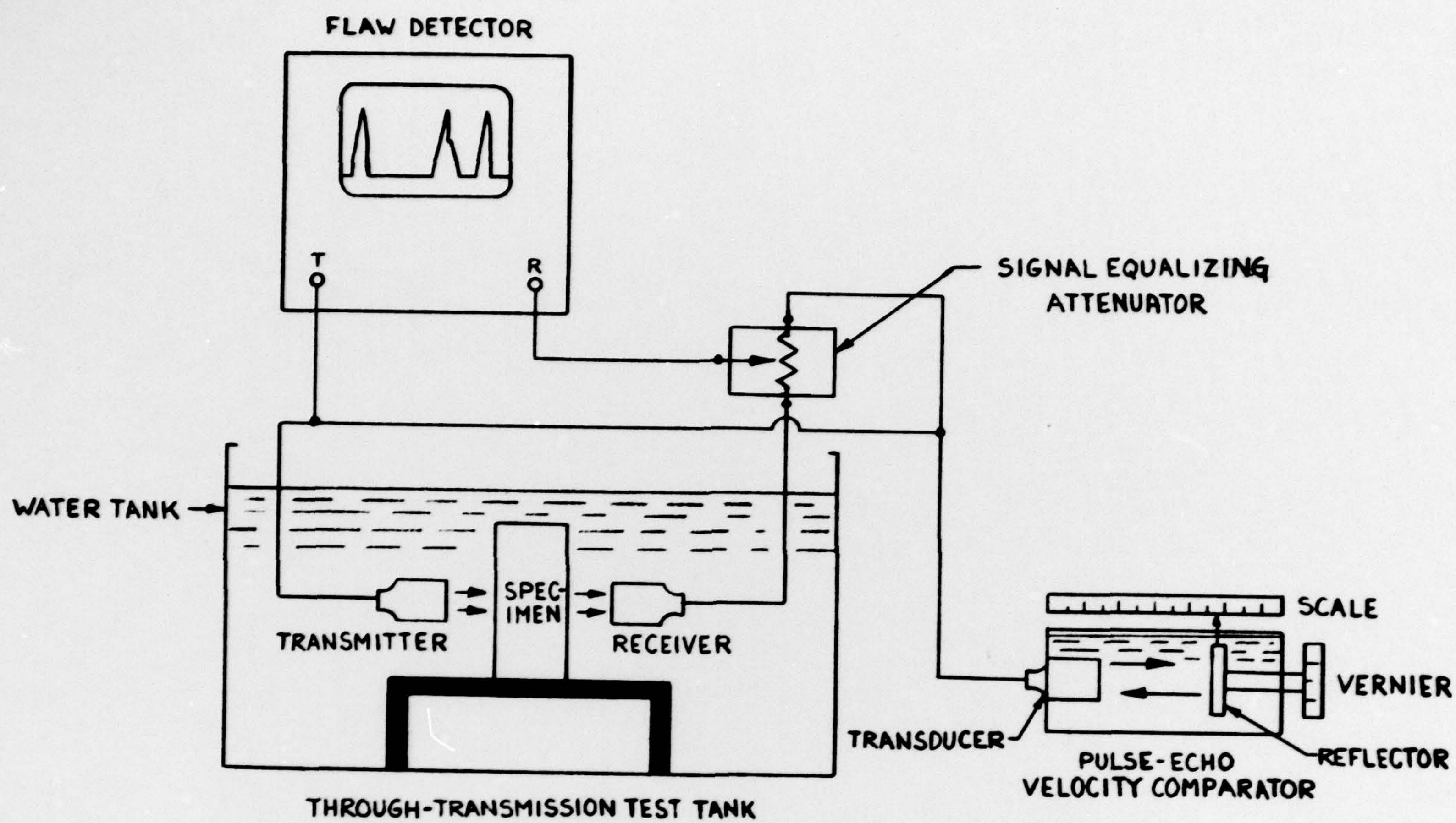

PHOTO L-21633-4

FIGURE 4 - SCHEMATIC DIAGRAM OF ULTRASONIC VELOCITY MEASURING SYSTEM

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